taneously, or in succession. Naturally, it is the stronger plants which most frequently multiply thus, but plants of a smaller number of protophylls may branch in this way. One plant of a single protophyll was found with two tubers forming.

The occasional occurrence of branching in the strobilus might be interpreted as an indication that the ancestors of the plant were once more abundantly branched. But it would be possible to take the opposite view that such branching is a nascent feature, that it is a new feature in the phylogeny. Bertrand regarded Phylloglossum as a form reduced on account of its semi-aquatic mode of life. But it is necessary to point out that Phylloglossum is not a semi-aquatic; Bertrand never had the advantage of seeing the plant in its native home. Phylloglossum, it is true, being a very small plant, can only grow whilst the surface soil is fairly moist, hence it forms a tuber and rests during the dry season. So far as I have seen, the plant grows rather better on a hill-top; or, at any rate, it grows there at least as well as it does lower down on the slope, and I have never found it in an actual swamp. It grows well on a slope where water can never lodge. Its roots spread rather horizontally, and seldom far downwards in the ground, as though it objected to a waterlogged soil.

Whilst it is possible that evidence may yet be adduced that Phylloglossum in some measure owes its simplicity to reduction, there appears to be little evidence for this at present. On the other hand, it may yet prove that Phylloglossum is an exceedingly primitive plant, possibly the most primitive of existing Pteridophytes. We have an explanation ready to hand of this exceptional retention of ancient characters, namely, the annual renewal of the embryonic stage in the formation of the protocorm. But however this may be decided, the relatively simple character of the gametophyte and the comparison of the mature sporophyte with the embryo of *Lycopodium cernuum* are in favour of the view that Phylloglossum is the most primitive of existing Lycopodinæ.

"Notes on the Development of *Paludina vivipara,* with Special Reference to the Urinogenital Organs and Theories of Gasteropod Torsion. (Preliminary Note.)" By ISABELLA M. DRUMMOND. Communicated by Professor W. F. R. WELDON, F.R.S. Received November 26,—Read December 5, 1901.

I. *The Urinogenital Organs.*

Von Erlanger, in his work on the development of Paludina, made known for the first time the existence, at an early stage of development, of a rudimentary kidney belonging to the original left side of

the body. He describes it as formed in the same manner as the definitive kidney, that is, as an evagination of the pericardial wall. According to him, at a fairly early stage it degenerates, together with the ingrowth of the mantle cavity, which formed its rudimentary duct, and a later evagination of the pericardial wall in an almost identical position gives rise to the gonad. This soon loses its connection with the pericardium and becomes vesicular, while an ingrowth of the mantle cavity, presumably the arrested kidney duct, grows towards it and finally fuses with it to form the gonaduct.

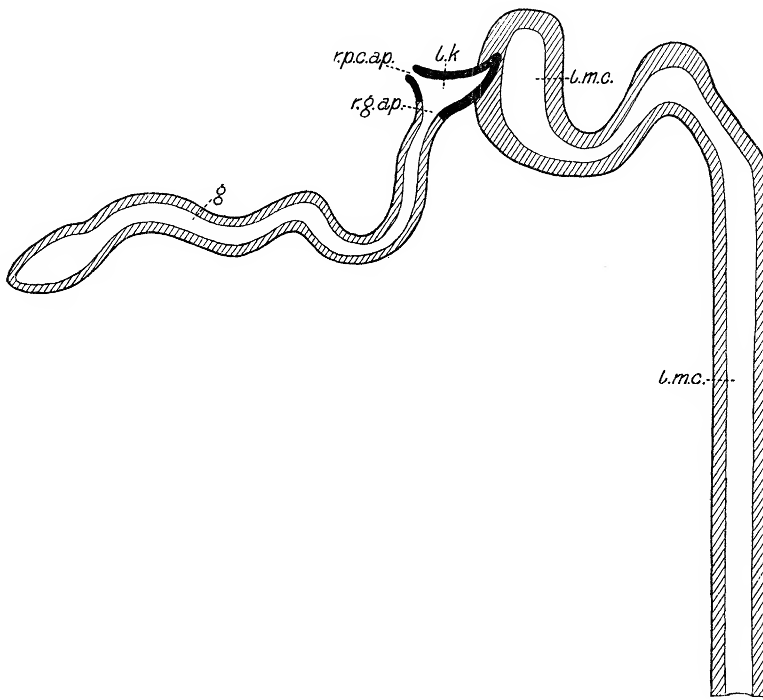
With the earliest stages of development as thus described the present researches are in complete harmony. At a time, however, when, according to von Erlanger, the rudimentary left kidney should have completely disappeared, it is found to be still present, and to show the normal relations both to the pericardium and the duct. No tendency to retrogressive development could be found in either the left kidney itself or in its duct. The development of the gonad also is not what von Erlanger describes it to be, for, whereas the kidney is an evagination of the original ventral wall of the pericardium, the gonad arises as a solid proliferation of the dorsal wall, and is connected with the kidney by a thickened ridge of pericardial epithelium. The originally solid gonad becomes secondarily hollowed out, and its lumen communicates with that of the kidney by means of this thickening, which also acquires a lumen.

In the adult, therefore, the genital organs may be considered as consisting of four distinct parts: (1) the gonad itself; (2) a specialised portion of the cœlom represented by the lumen of the pericardial ridge; (3) the kidney of the adult right side, through which the genital products must pass to reach (4) the ureter of the definitive right side, transformed into a gonaduct. These parts are shown in the figure, which represents a longitudinal section through the genital organs before maturity is reached. The long tubular gonad is seen at *g*. The second division is indistinguishable at so late a stage, but must be represented by the proximal portion of the gonad, and opens into the kidney (*l. k*) at *r. g. ap.* The reno-pericardial aperture (*r. p. c. ap.*) is still open, but will close before maturity. The duct is seen at *l. m. c.*

II. *Theories of Torsion.*

There are two main schools of thought which have to be considered —that of which Bütschli and, more recently, Plate are the chief exponents, and that which is upheld by Pelseneer, Amaudrut, and Boutan. Whereas the former uphold that unequal growth of the left side of the body is an efficient ontogenetic cause of the torsion of the Gasteropoda, the latter school believe that an actual twist of the body upon the head through an angle of 180° takes place in the course of development.

A renewed investigation of the development of Paludina shows that Bütschli's interpretation of it is open to much criticism. His point concerning the actual distance between mouth and anus remaining always the same is valueless, unless the mantle cavity be regarded as entirely formed by invagination. Even on the latter supposition rapid development of the original right division of the mantle cavity, at a time when torsion is being produced, shows that there is actually great activity in Bütschli's zone of cessation of growth.



Plate's suggestion that the liver, by its rapid growth on one side, alone brings about the asymmetry of the whole body is unsatisfactory, in that while torsion goes forward most rapidly the liver is almost stationary in its growth, while its chief development takes place after torsion is complete.

More fundamental than the above is the change in the position of organs which takes place through ontogeny. Bütschli and Plate have no explanation to offer of any displacement of organs in a vertical direction. A careful study of successive stages, however, reveals an orderly rotation of all the organs, whereby those originally dorsal become ventral, and *vice versâ*. This can probably only be explained

on some such view as that put forward by Pelseneer, and this is further confirmed by evidence, during the stages in which torsion is being effected, of an actual twist of the œsophagus, which keeps pace exactly with the torsion of the whole body.

Various monstrosities were found, which all lent support to Pelseneer's hypothesis rather than to Bütschli's. Chief of these was a well-developed untwisted form, with symmetrical mantle cavity and kidneys, and a strong tendency towards exogastric coiling of the visceral hump.

With regard to the ontogenetic cause of torsion merely negative evidence was found. That it is almost certainly not due to antagonism of growth between the foot and the visceral hump is shown by a comparison between normal forms and monstrosities.

"On the Intimate Structure of Crystals. Part V.—Cubic Crystals with Octahedral Cleavage." By W. J. Sollas, D.Sc., LL.D., F.R.S., Professor of Geology in the University of Oxford.

Received April 10,—Read May 23, 1901.

During the three years that have elapsed since the last part of this contribution was communicated to the Society, continued reflection has served only to confirm my belief that it is to the molecular volumes of crystalline matter we must turn for insight into its structure. There are several points of detail in which the results already obtained might be usefully modified, but the discussion of these may safely be postponed for the present, while we pass on to more important matters. For we have now reached a critical point in our enquiry, we propose to investigate more complex compounds than those hitherto considered, compounds also distinguished by a different crystalline structure. If we find, and I think we shall, that the constituent atoms of these compounds retain the specific volumes, which were determined from a study of very different cases, then our hypothesis will begin to appear less speculative, and we shall be able with greater confidence to extend our enquiries in other directions.

Triatomic compounds of the type H_2O are frequently represented graphically in the way shown by fig. 1. Molecules in which the atoms

Fig. 1.

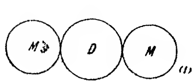
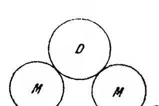


Fig. 2.



M, Monad; *D*, Dyad atom.